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Structural Analysis of Beams Formulas

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List of 26 Structural Analysis of Beams Formulas

Structural Analysis of Beams

1) Area to Maintain Stress as Wholly Compressive given Eccentricity

Open Calculator

fx $$A = \frac{Z}{e'}$$

ex $$5600\text{mm}^2 = \frac{1120000\text{mm}^3}{200\text{mm}}$$

2) Beam Breadth of Uniform Strength for Simply Supported Beam when Load is at Centre

Open Calculator

fx $$B = \frac{3 \cdot P \cdot a}{\sigma \cdot d_e^2}$$

ex $$96.95291\text{mm} = \frac{3 \cdot 0.15\text{kN} \cdot 21\text{mm}}{1200\text{Pa} \cdot (285\text{mm})^2}$$

3) Beam Depth of Uniform Strength for Simply Supported Beam when Load is at Centre

Open Calculator

fx $$d_e = \sqrt{\frac{3 \cdot P \cdot a}{B \cdot \sigma}}$$

ex $$280.6239\text{mm} = \sqrt{\frac{3 \cdot 0.15\text{kN} \cdot 21\text{mm}}{100.0003\text{mm} \cdot 1200\text{Pa}}}$$

4) Breadth for Rectangular Section to Maintain Stress as Wholly Compressive

Open Calculator

fx $$t = 6 \cdot e'$$

ex $$1200\text{mm} = 6 \cdot 200\text{mm}$$

5) Eccentricity for Rectangular Section to maintain Stress as Wholly Compressive

Open Calculator

fx $$e' = \frac{t}{6}$$

ex $$200\text{mm} = \frac{1200\text{mm}}{6}$$

6) Eccentricity for Solid Circular Sector to Maintain Stress as Wholly Compressive

Open Calculator

fx $$e' = \frac{\Phi}{8}$$

ex $$95\text{mm} = \frac{760\text{mm}}{8}$$

7) Eccentricity in Column for Hollow Circular Section when Stress at Extreme Fibre is Zero

Open Calculator

fx $$e' = \frac{D^2 + d_i^2}{8 \cdot D}$$

ex $$1281.25\text{mm} = \frac{(4000\text{mm})^2 + (5000\text{mm})^2}{8 \cdot 4000\text{mm}}$$

8) Eccentricity to Maintain Stress as Wholly Compressive

Open Calculator

fx $$e' = \frac{Z}{A}$$

ex $$200\text{mm} = \frac{1120000\text{mm}^3}{5600\text{mm}^2}$$

9) Loading of Beam of Uniform Strength

Open Calculator

fx $$P = \frac{\sigma \cdot B \cdot d_e^2}{3 \cdot a}$$

ex $$0.154715\text{kN} = \frac{1200\text{Pa} \cdot 100.0003\text{mm} \cdot (285\text{mm})^2}{3 \cdot 21\text{mm}}$$

10) Section Modulus to Maintain Stress as Wholly Compressive given Eccentricity

Open Calculator

fx $$Z = e' \cdot A$$

ex $$1.1\text{E}^\wedge 6\text{mm}^3 = 200\text{mm} \cdot 5600\text{mm}^2$$

11) Stress of Beam of Uniform Strength

Open Calculator

fx $$\sigma = \frac{3 \cdot P \cdot a}{B \cdot d_e^2}$$

ex $$1163.431\text{Pa} = \frac{3 \cdot 0.15\text{kN} \cdot 21\text{mm}}{100.0003\text{mm} \cdot (285\text{mm})^2}$$

Continuous Beams

12) Absolute Value of Maximum Moment in Unbraced Beam Segment

Open Calculator

fx $$M'max = \frac{M_{coeff} \cdot ((3 \cdot M_A) + (4 \cdot M_B) + (3 \cdot M_C))}{12.5 - (M_{coeff} \cdot 2.5)}$$

ex $$50.23317N*m = \frac{1.32N*m \cdot ((3 \cdot 30N*m) + (4 \cdot 50.02N*m) + (3 \cdot 20.01N*m))}{12.5 - (1.32N*m \cdot 2.5)}$$

13) Condition for Maximum Moment in Interior Spans of Beams

Open Calculator

fx $$x'' = \left(\frac{Len}{2}\right) - \left(\frac{M_{max}}{q \cdot Len}\right)$$

ex $$1.499666m = \left(\frac{3m}{2}\right) - \left(\frac{10.03N*m}{10.0006kN/m \cdot 3m}\right)$$

14) Condition for Maximum Moment in Interior Spans of Beams with Plastic Hinge

Open Calculator

fx $$x = \left(\frac{Len}{2}\right) - \left(\frac{k \cdot M_p}{q \cdot Len}\right)$$

ex $$1.24984m = \left(\frac{3m}{2}\right) - \left(\frac{0.75 \cdot 10.007kN*m}{10.0006kN/m \cdot 3m}\right)$$

15) Ultimate Load for Continuous Beam

Open Calculator

fx $$U = \frac{4 \cdot M_p \cdot (1 + k)}{Len}$$

ex $$23.34967kN = \frac{4 \cdot 10.007kN*m \cdot (1 + 0.75)}{3m}$$

Elastic Lateral Buckling of Beams

16) Absolute Value of Moment at Centerline of Unbraced Beam Segment

Open Calculator

fx $$M_B = \frac{(12.5 \cdot M'max) - (2.5 \cdot M'max + 3 \cdot M_A + 3 \cdot M_C)}{4}$$

ex $$87.5175N*m = \frac{(12.5 \cdot 50.01N*m) - (2.5 \cdot 50.01N*m + 3 \cdot 30N*m + 3 \cdot 20.01N*m)}{4}$$

17) Absolute Value of Moment at Quarter Point of Unbraced Beam Segment

Open Calculator

fx $$M_A = \frac{(12.5 \cdot M'max) - (2.5 \cdot M'max + 4 \cdot M_B + 3 \cdot M_C)}{3}$$

ex $$79.99667N*m = \frac{(12.5 \cdot 50.01N*m) - (2.5 \cdot 50.01N*m + 4 \cdot 50.02N*m + 3 \cdot 20.01N*m)}{3}$$

18) Absolute Value of Moment at Three-Quarter Point of Unbraced Beam Segment

Open Calculator

fx $$M_C = \frac{(12.5 \cdot M'max) - (2.5 \cdot M'max + 4 \cdot M_B + 3 \cdot M_A)}{3}$$

ex $$70.00667N*m = \frac{(12.5 \cdot 50.01N*m) - (2.5 \cdot 50.01N*m + 4 \cdot 50.02N*m + 3 \cdot 30N*m)}{3}$$

19) Critical Bending Coefficient

Open Calculator

fx $$M_{coeff} = \frac{12.5 \cdot M'max}{(2.5 \cdot M'max) + (3 \cdot M_A) + (4 \cdot M_B) + (3 \cdot M_C)}$$

ex $$1.315679N*m = \frac{12.5 \cdot 50.01N*m}{(2.5 \cdot 50.01N*m) + (3 \cdot 30N*m) + (4 \cdot 50.02N*m) + (3 \cdot 20.01N*m)}$$

20) Critical Bending Moment for Simply Supported Open Section Beam

Open Calculator

fx $$M_{cr} = \left(\frac{\pi}{L}\right) \cdot \sqrt{E \cdot I_y \cdot \left((G \cdot J) + E \cdot C_w \cdot \left(\frac{\pi^2}{(L)^2}\right)\right)}$$

ex

$$9.802145N*m = \left(\frac{\pi}{10.04cm}\right) \cdot \sqrt{10.01MPa \cdot 10.001kg{\cdot}m^2 \cdot \left((100.002N/m^2 \cdot 10.0001) + 10.01MPa \cdot 10.0005\right.}$$

21) Critical Bending Moment for Simply Supported Rectangular Beam

Open Calculator

fx $$M_{Cr(Rect)} = \left(\frac{\pi}{Len}\right) \cdot \left(\sqrt{e \cdot I_y \cdot G \cdot J}\right)$$

ex $$740.5286N*m = \left(\frac{\pi}{3m}\right) \cdot \left(\sqrt{50Pa \cdot 10.001kg{\cdot}m^2 \cdot 100.002N/m^2 \cdot 10.0001}\right)$$

22) Critical Bending Moment in Non-Uniform Bending

Open Calculator

fx $M'_{cr} = \left(M_{coeff} \cdot M_{cr}\right)$

ex $13.2\text{N*m} = \left(1.32\text{N*m} \cdot 10\text{N*m}\right)$

23) Elasticity Modulus given Critical Bending Moment of Rectangular Beam

Open Calculator

fx $e = \frac{\left(M_{Cr(Rect)} \cdot Len\right)^2}{\left(\pi^2\right) \cdot I_y \cdot G \cdot J}$

ex $50.06367\text{Pa} = \frac{\left(741\text{N*m} \cdot 3\text{m}\right)^2}{\left(\pi^2\right) \cdot 10.001\text{kg·m}^2 \cdot 100.002\text{N/m}^2 \cdot 10.0001}$

24) Minor Axis Moment of Inertia for Critical Bending Moment of Rectangular Beam

Open Calculator

fx $I_y = \frac{\left(M_{Cr(Rect)} \cdot Len\right)^2}{\left(\pi^2\right) \cdot e \cdot G \cdot J}$

ex $10.01374\text{kg·m}^2 = \frac{\left(741\text{N*m} \cdot 3\text{m}\right)^2}{\left(\pi^2\right) \cdot 50\text{Pa} \cdot 100.002\text{N/m}^2 \cdot 10.0001}$

25) Shear Elasticity Modulus for Critical Bending Moment of Rectangular Beam

Open Calculator

fx $G = \frac{\left(M_{Cr(Rect)} \cdot Len\right)^2}{\left(\pi^2\right) \cdot I_y \cdot e \cdot J}$

ex $100.1294\text{N/m}^2 = \frac{\left(741\text{N*m} \cdot 3\text{m}\right)^2}{\left(\pi^2\right) \cdot 10.001\text{kg·m}^2 \cdot 50\text{Pa} \cdot 10.0001}$

26) Unbraced Member Length given Critical Bending Moment of Rectangular Beam

Open Calculator

fx $Len = \left(\frac{\pi}{M_{Cr(Rect)}}\right) \cdot \left(\sqrt{e \cdot I_y \cdot G \cdot J}\right)$

ex $2.998092\text{m} = \left(\frac{\pi}{741\text{N*m}}\right) \cdot \left(\sqrt{50\text{Pa} \cdot 10.001\text{kg·m}^2 \cdot 100.002\text{N/m}^2 \cdot 10.0001}\right)$

Variables Used

- **a** Distance from A end *(Millimeter)*
- **A** Area of Cross-Section *(Square Millimeter)*
- **B** Width of Beam Section *(Millimeter)*
- **C_w** Warping Constant *(Kilogram Square Meter)*
- **D** Outer Depth *(Millimeter)*
- **d_e** Effective Depth of Beam *(Millimeter)*
- **d_i** Inner Depth *(Millimeter)*
- **e** Elastic Modulus *(Pascal)*
- **e'** Eccentricity of Load *(Millimeter)*
- **E** Modulus of Elasticity *(Megapascal)*
- **G** Shear Modulus of Elasticity *(Newton per Square Meter)*
- **I_y** Moment of Inertia about Minor Axis *(Kilogram Square Meter)*
- **J** Torsional Constant
- **k** Ratio between Plastic Moments
- **L** Unbraced Length of Member *(Centimeter)*
- **Len** Length of Rectangular Beam *(Meter)*
- **M_A** Moment at Quarter Point *(Newton Meter)*
- **M_B** Moment at Centerline *(Newton Meter)*
- **M_C** Moment at Three-quarter Point *(Newton Meter)*
- **M_{coeff}** Bending Moment Coefficient *(Newton Meter)*
- **M_{cr}** Critical Bending Moment *(Newton Meter)*
- **M'_{cr}** Non-Uniform Critical Bending Moment *(Newton Meter)*
- **$M_{Cr(Rect)}$** Critical Bending Moment for Rectangular *(Newton Meter)*
- **M_{max}** Maximum Bending Moment *(Newton Meter)*
- **M_p** Plastic Moment *(Kilonewton Meter)*
- **M'max** Maximum Moment *(Newton Meter)*
- **P** Point Load *(Kilonewton)*
- **q** Uniformly Distributed Load *(Kilonewton per Meter)*
- **t** Dam Thickness *(Millimeter)*
- **U** Ultimate Load *(Kilonewton)*
- **x** Distance of point where Moment is Maximum *(Meter)*
- **x''** Point of Maximum Moment *(Meter)*
- **Z** Section Modulus for Eccentric Load on Beam *(Cubic Millimeter)*
- **σ** Stress of Beam *(Pascal)*
- **Φ** Diameter of Circular Shaft *(Millimeter)*

Constants, Functions, Measurements used

- Constant: **pi**, 3.14159265358979323846264338327950288
  Archimedes' constant
- Function: **sqrt**, sqrt(Number)
  Square root function
- Measurement: **Length** in Millimeter (mm), Meter (m), Centimeter (cm)
  Length Unit Conversion
- Measurement: **Volume** in Cubic Millimeter (mm³)
  Volume Unit Conversion
- Measurement: **Area** in Square Millimeter (mm²)
  Area Unit Conversion
- Measurement: **Pressure** in Pascal (Pa), Megapascal (MPa), Newton per Square Meter (N/m²)
  Pressure Unit Conversion
- Measurement: **Force** in Kilonewton (kN)
  Force Unit Conversion
- Measurement: **Surface Tension** in Kilonewton per Meter (kN/m)
  Surface Tension Unit Conversion
- Measurement: **Moment of Inertia** in Kilogram Square Meter (kg·m²)
  Moment of Inertia Unit Conversion
- Measurement: **Moment of Force** in Newton Meter (N*m), Kilonewton Meter (kN*m)
  Moment of Force Unit Conversion

Check other formula lists

- **Eccentric Loading Formulas**
- **Structural Analysis of Beams Formulas**
- **Unsymmetrical Bending and Three Hinged Arches Formulas**

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